MORPHOMETRY OF WRINKLE RIDGES ON VENUS: COMPARISON WITH OTHER PLANETS. *M. A. Kreslavsky*[1,2] *and A. T. Basilevsky*[3], [1]Dept. Geosci. and Astronomy, Oulu Univ., Oulu, Finland, [2]Kharkov Astronomical observatory, Kharkov, Ukraine (kreslavsky@mak.kharkov.ua), [3]Vernadsky Institute, Moscow, Russia

Introduction. Wrinkle ridges are known on all terrestrial bodies. They are thought to be compressional tectonic features resulted from folding followed by faulting or faulting followed by folding of a strong near-surface layer above weaker material [e.g., 1]. T. Watters measured frequency distributions of distances between wrinkle ridges for 15 areas on the Tharsis Plateau on Mars, where the ridges form quasi-periodical regional systems [2]. He also measured widths and heights of 185 wrinkle-ridges-related features on the Moon, Mars, and Mercury and subdivided them into ridges (with typical width/height ratio ≈ 10) and arches (width/height ≈ 70) [1]. On Venus, wrinkle ridges [3, 4] are more abundant than on other planets. They are common tectonic features on vast plains that occupy about 70% of Venus surface and play a key role in stratigraphy of Venus [e.g., 5]. In this paper we report our measurements of Venusian wrinkle ridges morphometry and spacing of their net. Then we compare our results with T. Watters' data for other planets.

Observations and Results. To study wrinkle ridge *spacing* we chose 30 random sites on plains with wrinkle ridges. Fore each site a line segment of 200 km length was plotted on the full resolution Magellan mosaic in the direction normal to dominant orientation of wrinkle ridges in the region. Distances between intersections of neighbouring ridges with the line were measured. Totally 8…38 distances were measured for each site.

For each of 30 sites we estimated *width* of the ridges at 9…18 points in an area about 50 km around the segment. Special attention was paid for distinguishing ridges feet from associated aeolean features. In many cases ridge feet were not seen on radar images at all [4]. In these cases that is seen on images is probably ridges' crests. Often they are sinuous in small-scale, probably because the crest wanders from foot to foot of an unseen arch, which is typical for ridges on other planets. In these cases we estimate the ridge widths as characteristic widths of this small-scale wandering. Finally, in many cases there is no small-scale sinuosity, and wrinkle ridges are seen in radar image just like lineaments whose width is apparently smaller than image resolution. In these cases we assume estimation of 230 m for the width (this is the worst resolution of images used). It is seen that measurements of widths are somewhat ambiguous, however they do give certain idea about systematic changes in widths from site to site.

Locations of all 30 sites, mean values of measured spacing and width and their standard deviations are listed in the **Table**.

Site		Spacing, km		Width, km	
Lat ^{0}	Lon ^{0}	Mean	StDev	Mean	StDev
70.0	328.0	9.3	3.7	0.4	0.3
64.0	294.6	8.8	4.5	1.3	0.5
53.0	176.5	8.7	3.5	1.2	0.9
49.0	143.5	17.3	9.3	2.4	1.2
44.0	1.0	15.9	7.9	1.3	1.0
41.5	269.0	21.4	6.5	1.3	0.7
34.0	199.5	8.9	7.1	1.4	0.6
28.5	161.5	12.6	8.3	1.5	0.8
23.5	5.0	10.8	6.6	0.8	0.8
18.5	334.0	18.6	10.9	0.6	0.4
17.0	184.0	4.8	3.4	0.3	0.3
12.0	32.0	8.9	4.8	1.8	0.9
11.0	100.0	11.3	6.6	0.3	0.3
4.0	181.5	14.9	7.5	1.5	0.6
-1.5	44.5	10.7	6.9	1.2	0.4
-1.5	188.5	21.9	10.0	0.5	0.4
-4.5	313.0	13.2	8.0	1.3	0.5
-8.0	51.5	6.7	4.0	1.9	1.3
-16.5	50.0	7.6	3.9	0.9	0.5
-19.0	354.5	7.4	3.1	0.4	0.4
-20.5	161.0	21.1	9.4	2.7	0.8
-23.0	12.0	14.0	9.4	1.0	0.4
-29.0	210.0	12.1	4.6	1.6	0.8
-37.0	202.0	9.9	6.2	1.4	0.4
-42.0	290.5	9.7	6.5	1.6	0.8
-44.0	141.5	32.6	14.7	2.7	1.9
-49.0	90.0	13.4	8.9	0.6	0.5
-54.0	101.0	9.5	6.4	0.4	0.3
-62.5	206.5	9.7	5.0	1.5	0.5
-66.5	191.5	14.7	8.3	1.7	0.7

We attempted to estimate *height* of wrinkle ridges, especially for the site at 20.5^0 S, 161.0^0 E (**Fig. 1**). The ridges are rather wide here, and images for all 3 cycles of Magellan survey, that is for 3 different viewing geometry, are available. Measurements based on radar stereo view [e.g., 6], are seldom possible, because it is too difficult to identify features on ridge tops at opposite radar view directions with necessary accuracy. In the point **A** (Fig. 1) in 1.8 km wide ridge the central bright feature is apparently the crest, and the eastern and western features are probably the arch feet, maybe complicated with secondary ridges. Stereo view gives 40…90 m limits for height difference between the crest and the feet.

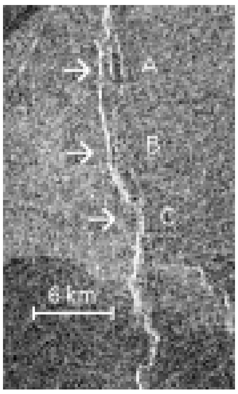

Fig. 1

Height measurements based on difference in lengthening and shortening of slopes at different looks (e.g., [6]) are of very low accuracy. Apparent widths of shortened slopes faced toward radar are usually under the resolution, so only an upper limit of the width can be estimated. Margins of lengthened slopes faced in

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the opposite direction are difficult to identify accurately. For points **B** and **C** (Fig. 1), where ridges are about 2.5 km wide, this method gives the height limits of 140...260 m and 50...170 m respectively.

Application of ideas of subresolution clinometry [7] is difficult because of the following reasons. First, small-scale variations of radar brightness are significant, so it is almost impossible to find good areas for averaging data in order to reduce the noise. Second, slope profiles apparently vary from site to site in wide range, so it is difficult to do any a priori assumption about them. Of course, topography of ridges, whose width cannot be resolved, cannot be estimated from radar images. Beside three points in Fig. 1 we estimated height of ridges in some other sites and get comparable results. However, global uniform systematic survey of ridge topography using Magellan radar images is impossible.

Comparison with Other Planets and Discussion. In **Fig. 2** statistical characteristics of average *width* for our 30 sites (minimum, mean, mean ± standard deviation, and maximum) are compared with similar data for the Moon, Mars and Mercury [1]. It is clearly seen that ridges on Venus are sufficiently narrower than on other planets. Our rough estimations of ridge *height* showed that height/width ratio for the wrinkle ridges on Venus is of the same order of magnitude as on other planets. The latter is an additional evidence for similarity of wrinkle ridges origin on Venus and the other planets.

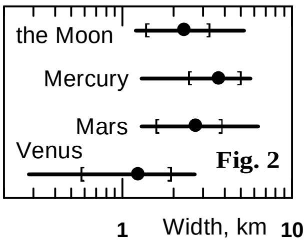

Fig. 2

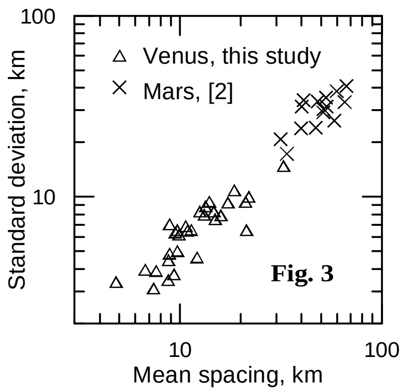

Fig. 3

Standard deviation of wrinkle ridge *spacing* for each site is sufficiently smaller than typical spacing value. It proves that wrinkle ridges are not distributed randomly, but tend to form quasiperiodic net. Mean values and standard deviations of wrinkle ridge spacing are compared with the similar data on Tharsis Plateau on Mars [2] in **Fig. 3**. It is clearly seen that spacing of ridges on Venus is systematically smaller than on Mars (global average for Venus is 13 km against 38 km for Mars), while variance (standard deviation referred to mean values) is almost the same. The latter is an additional evidence for similarity of wrinkle ridges formation mechanism on the planets. In **Fig. 4**, statistical characteristics of average spacing for our 30 sites (minimum, mean, mean ± standard deviation, and maximum) are compared with the same values for 15 areas in Tharsis Plateau from [2].

The relative decrease in global average of *both spacing and width* of wrinkle ridges on Venus in comparison to Tharsis Plateau is roughly the same, which imply roughly the same strain. However there is no prominent correlation between spacing and width of wrinkle ridges on Venus (**Fig. 5**).

Influence of difference in gravity on Mars and Venus on spacing of wrinkle ridges can be evaluated using elastic and viscose models considered in [2]. Both models assume layered structure with strong upper layer(s) and weak substrate. For the elastic model spacing is approximately proportional to $g^{-1/4}$ (g is acceleration due to gravity). For the viscose model depending on the set of other parameters the influence of gravity changes from proportionality to $g^{-1/2}$ to absence of any dependence. **Fig. 4** shows, how the Venus data can be scaled to Martian gravity using the most strong dependence ($\sim g^{-1/2}$). It is clearly seen that the gravity scaling cannot be responsible for all the difference in spacing. The most probable cause for the difference is generally thinner upper strong layer on Venus.

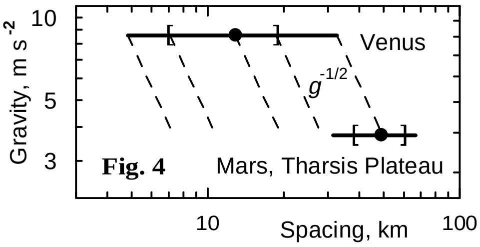

Fig. 4

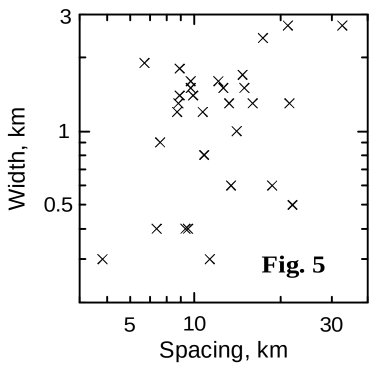

Fig. 5

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